Space Weather Technical Forecast

Issued on Tuesday, 23 January 2024 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME currently affecting Earth with further CME forecast on 25 January. Likelihood of G1/G2 storming from both events, with very slight chance of G3. Moderate solar activity expected. Chance of radiation storms throughout.
Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with multiple M-class flares observed initially from AR3559 (Fki/βγδ) in the northeast. Further flares have been observed from the rapidly developing AR3561 (Eai/βγδ) in the south central disc. This region has produced the peak flare of the last 24 hours, a M3.4 flare at 22/2121UTC. AR3560 showed some limited complexity but appears to be fading. The remaining regions appear to mature or stable. There are seven sunspot regions in total.

Within the last 24 hours, the most significant CME was from the south centre disc around 22/1000UTC. This has been modelled with a possible arrival on 25 January. Further apparent CMEs from the northwest and north centre disc will be analysed once sufficient imagery becomes available.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR, initially varied between slightly elevated and ambient, but increased to around 500km.s from 22/1600UTC due to the arrival of a CME which left the Sun on 20 January. This has since declined to 400-450km/s. Density started below average but increase to above average following the CME arrival, reaching a peak of 31ppcc at 22/2136UTC. Total magnetic field strength increased from weak to moderate levels, peaking at 13nT at 22/1713UTC and has remained at slightly weaker moderate levels since. Bz has varied moderately throughout, with a greater oscillation after the CME arrival, reaching a negative peak of -12nT at 22/1937UTC. Phi angle was mainly positive (away from the Sun). Resultant geomagnetic activity started Quiet but increased to Unsettled from 22/1800UTC.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux started to increase from normal background around 22/0100UTC, reaching a peak of 7pfu at 22/1635UTC before declining back towards background.

GOES16 high energy (greater than 2MeV) electron flux was at background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold on a steady trend. At 23/0001UTC the 24-hour integrated fluence observation was 1.88e6 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary
Solar Activity: M-class flares are expected throughout from AR3561 and the AR3559, with a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: The magnetic cloud from the current CME may decline during 23 January, but with low confidence in timing. A further CME is forecast to affect Earth on 25 January with a speed of around 650km/s, although there is uncertainty on whether this will be a glancing blow. There is also a low confidence in a glancing CME, also on 25 January. No significant coronal hole high speed streams are expected in the forecast period. There is a likelihood of G1/Minor or G2/Moderate storms on 23 January, with a declining risk on 24 January. A further risk of G1/Minor or G2/Moderate storms on 25 January due to the second CME arrival. This risk may then continue into 26 January.

Energetic Particles / Solar Radiation: There is a chance that the high energy proton flux (greater than 10MeV) could reach the S1 radiation storm threshold on 23 January but with a declining possibility through the day. Further risk of radiation storming through the period due to AR3559 and AR3561, which both carry a high risk of proton rich flaring.

The high energy electron flux may trend towards the high level as the effects of the CME ease, but with low probability. A further increase may then occur on 26 January following the second CME but with similar low probability. Electron fluence may trend toward the high threshold, but with a low risk of exceeding the Active threshold.

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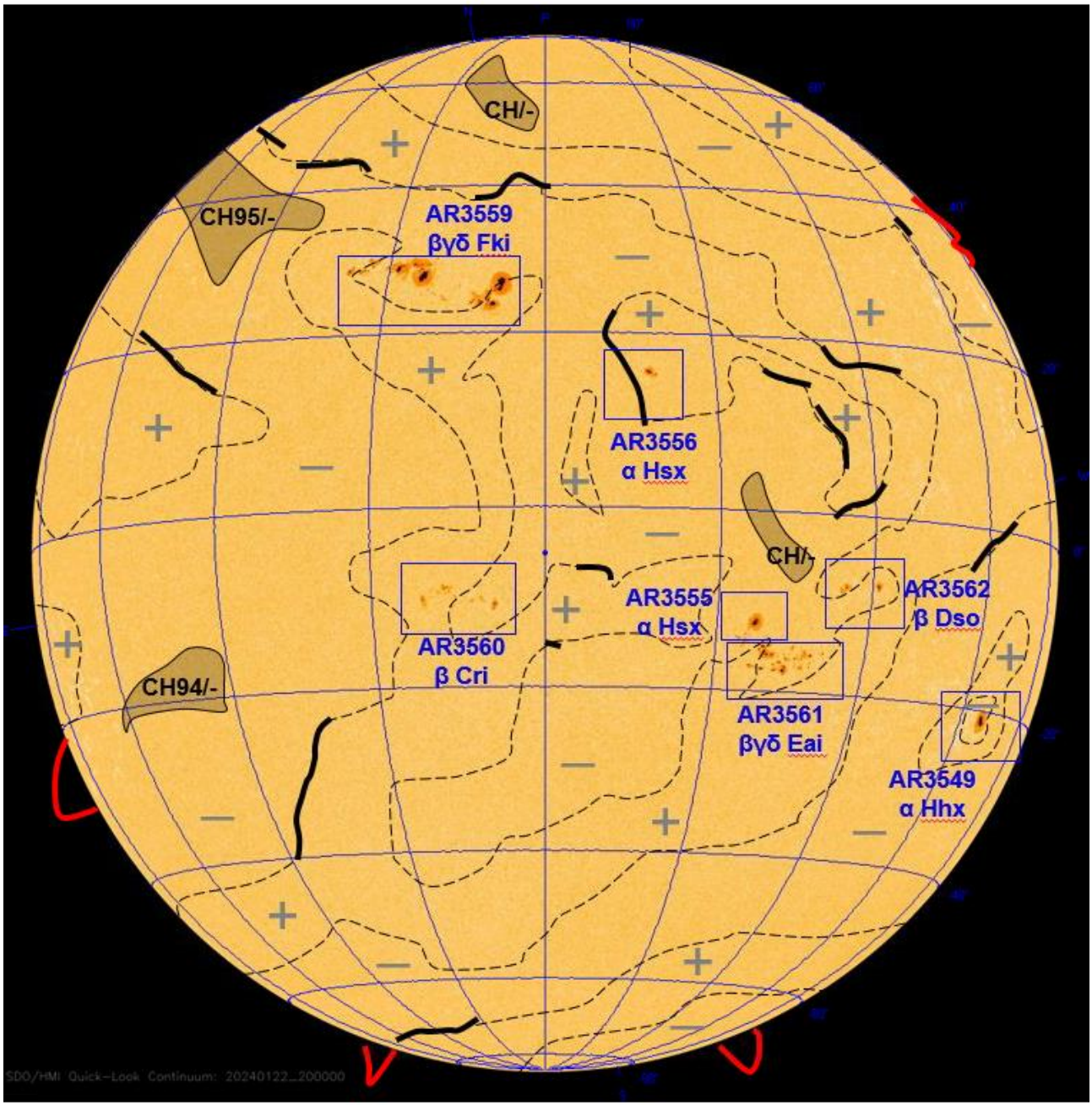
Figure 1. Solar Analysis Valid 22/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The Earth is under the influence of a currently low impact CME, which left the Sun on 20/0840UTC. This arrived at Earth around 22/1600UTC with a speed increase to around 500km/s and a modest, but consistent increase in density. Magnetic field strength reach moderate levels, but Bz was generally positive, or moderately negative, so no geomagnetic storming has been observed. However as the Earth now appears to be in the magnetic cloud from this CME, any sustained periods of negative Bz could lead to geomagnetic storming periods. A further CME which left the Sun from the region of AR3559 at 21/0015UTC is expected to miss the Earth, but with a low risk of a glancing impact on 23 January. A further CME which left the southeast of the Sun later on 21 January appears to have been modelled to pass underneath the Earth. A further larger eruption, which is evident on multiple imagery erupting from the south centre disc around 22/1000UTC is forecast to arrive at Earth on 25 January with a higher confidence, based on multiple fits of passing Earth orbit, but lower confidence in how much of the CME may affect the Earth.

Otherwise the solar wind appeared to have reached ambient levels early on 22 January as the Earth left the influence of recent coronal holes. A weak coronal hole has been identified in centre disc, but these are unlikely to enhance the solar wind significantly.

Geomagnetic activity may reach G1 or G2 storm levels due to any effects of the magnetic cloud which is affecting the Earth. Although there is inherent uncertainty in when the CME may fully pass the Earth, as reduction is risk is expected through 24 January. The further southeastern CME which is forecast to pass the Earth on 25 January may give G1/Minor or G2/Moderate Storm intervals on 25 January, with a risk of any effects continuing into 26 January.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	5	50	30
Strong	G3	No	5	1	10	5
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/1559	Partial	Filament eruption	South-centre disc	650km/s	25/1800UTC	Uncertainty in how direct the impact will be

Figure 2: L1/DSCOVR data for the last 24 hours with the CME impact signature clearly discernible.

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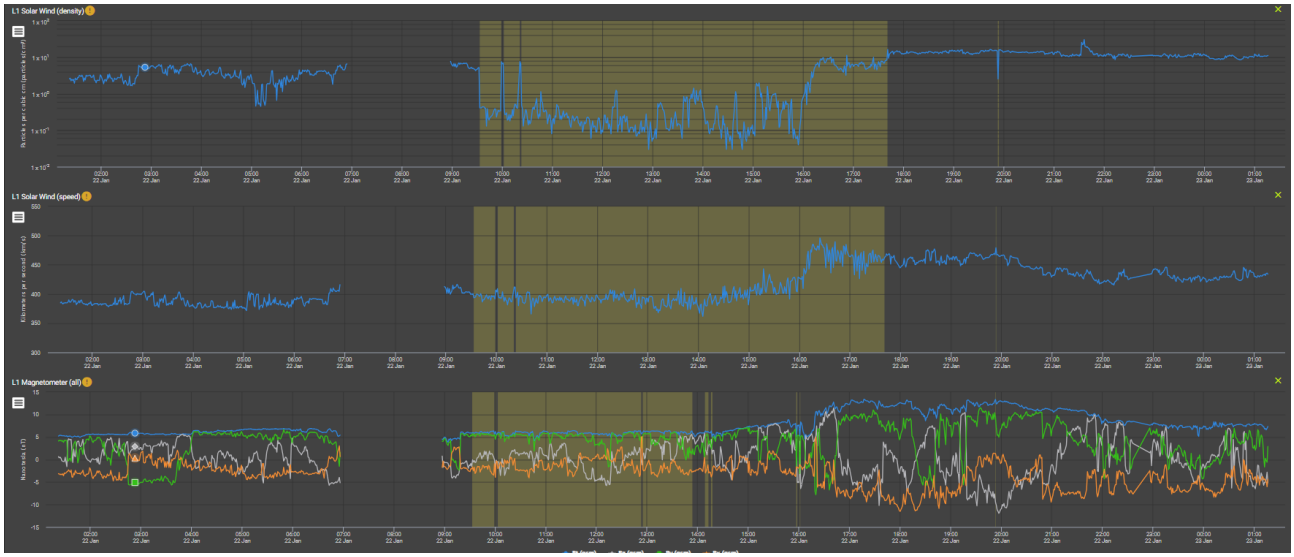
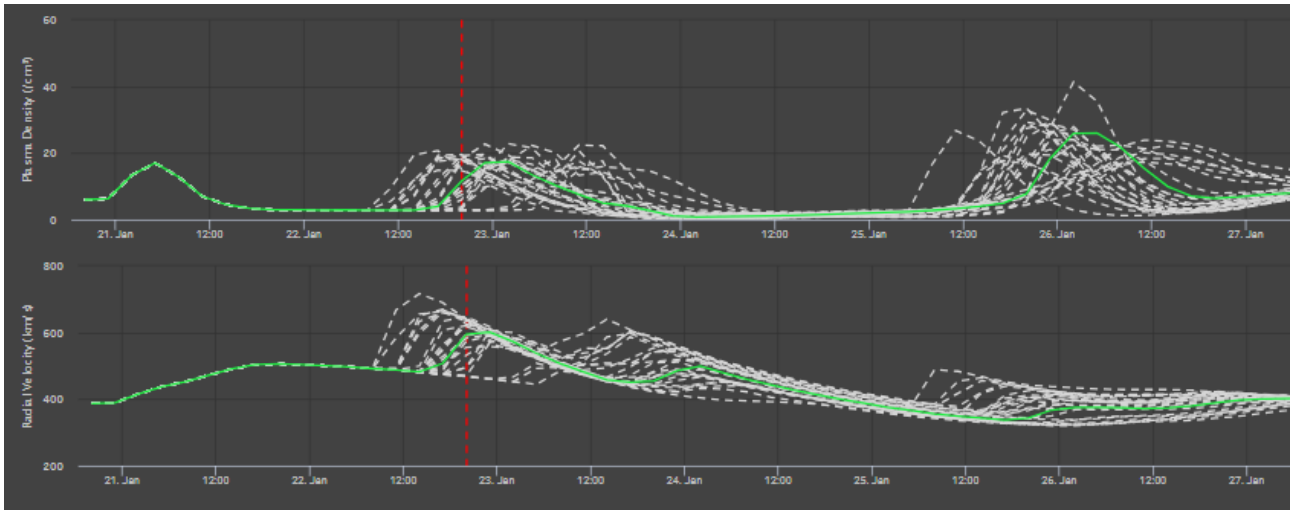


Figure 3: MOSWOC Enlil ensemble with the CME arrival on 25 January indicated by the increases in speed and plasma density.



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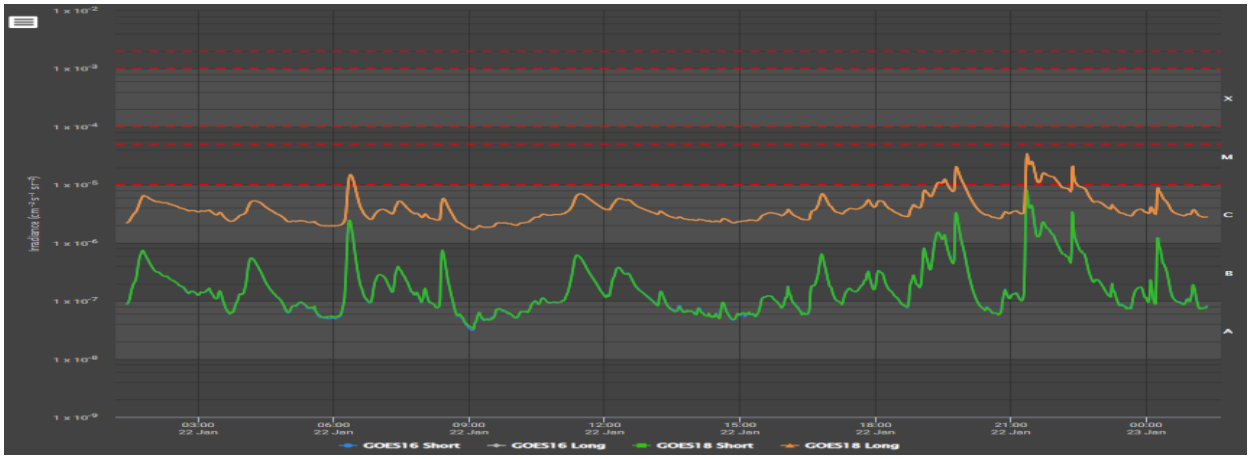
Radio Blackouts - X-Ray Flares:
AR3561 however has shown rapid development in both size and complexity over the last 24 hours, with a contorted delta spot in the centre of the group. This has taken over as the most active region on the visible disc, producing multiple M-class flares, these peaking at a M3.4 at 22/2121UTC. This is the highest risk region currently and continues to be monitored for further significant flare activity.
AR3559 is another large and extremely complex sunspot region in the northeast quadrant. This has been the most active region through the last 24 hours, with multiple C-class flares and two C-class flares. AR3560 is also showing limited signs of activity but has faded, so is likely to be weakening. The remaining regions are mature or stable.
Solar activity is expected to be mainly Moderate, with a chance of X-class flaring. This is likely to be mainly from AR3561, but with a possible contribution from AR3559. Due to the location of these regions, the risk if expected to continue through the next four days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 4: GOES 16 X-ray flux



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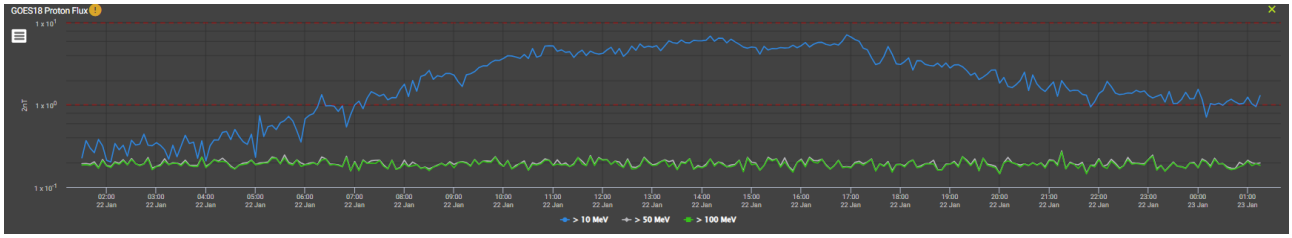
Solar Radiation Storms - (High Energy Protons):
GOES18 high energy (greater than 10MeV) proton flux is currently slightly elevated and on a rising trend. This increase appears to be a response ahead of the CME arrival early on 22 January. This level is already fading, although further CMEs, if they are associated with proton rich eruptions, could further enhance the proton response through the forecast period.

The risk of S1 radiation storming is maintained on 23 January due to the enhanced levels and recent CMEs. There is then a chance of radiation storms from 24 January, due to the high magnetic complexity of AR3561 in the western hemisphere and the imminent rotation of AR3559 into the western hemisphere during the next 24 hours.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	50	30	30	30
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES 18 Proton Flux



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High Energy Electrons Event (≥ 2MeV):
The high energy electron (greater than 2MeV) forecast is uncertain due to the effects of multiple CME arrivals on the forecast. The arrival on 22 January may have distorted the radiation belts away from GEO but an increased population, combined with a decreasing solar wind pressure as the effects of the CME passes the Earth, could lead to a sharp increase towards High levels. A further CME on 25 January could then disrupt this process with a further distortion of the belts and decrease in the observation of electron as GEO.

Electron fluence values reflect this uncertainty, with only a low probability of reaching the Active threshold, assuming a sharp and sustained increase in the electron flux. The probability increase have been modulated to match the potential effects of the CMEs.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	5	10	5	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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